OPERATORS HANDBOOK

TYPE 323 OSCILLOSCOPE

This handbook is a reference document on basic characteristics, operation, performance check, maintenance, and applications. Complete and detailed information is provided in the standard manual supplied with the instrument.

070-1155-00 1270

CONTENTS

ABRIDGED SPECIFICATIONS
(Electrical)

Complete updated specifications are provided in the Instruction manual.

Characteristic	Performance Requirement
Deflection Factor	
Accuracy	Within 3% of VOLTS/DIV indication.
Input R & C	1 MΩ ±2%, 45 pF ±4 pF.
Bandwidth/Rise-time	
X1 Gain	At least 4 MHz (90 ns)
X10 Gain	At least 2.75 MHz (130 ns)
Low Frequency (–3 dB) Point, AC Coupled	2 Hz or less
Maximum Input Voltage	500 V (DC + peak AC) with or without probe
Step Response	
Aberrations	Within 3% (total peak to peak)
Overload Recovery	Within 1 μs after a signal change, at the VERT INPUT, of ±30 divisions of deflection.

Characteristic	Performance Requirement
Trigger Sensitivity	
Internal	0.3 div. to 400 kHz increasing to 0.75 div. for 4 MHz
External	75 mV to 400 kHz increasing to 190 mV for 4 MHz. (Signal applied to EXT TRIGGER INPUT connector, ATTEN set to 1X position. Increase signal level for 10X position of the ATTEN switch.)
AC Coupled, including AUTO	Sensitivity decreases sharply below 30 Hz
ACLF REJ Mode	Sensitivity decreases sharply below 30 kHz.
External Trigger Input R & C	1 MΩ ±2%, 62 pF ±4 pF
Maximum Input Voltage	300 V (DC + peak AC)
Horizontal Sweep Timing Accuracy (with VARiable control in CAL position)	
Unmagnified	5 μs/div to 0.2 s/div, within 3%
	0.5 s/div to 1 s/div, within 4%

Characteristic	Performance Requirement
Magnified	2 μs/div to 20 ms/div., within 4%
	0.5 μs/div, 1.0 μs/div. 50 ms/div, and 0.1 s/div, within 5%
External Horizontal Input Deflection Factor	200-300 mV/div.
Square Wave Calibrator	
Amplitude	0.5 V, ±2% (peak to peak).
Frequency	Approximately 850 Hz
Risetime (leading edge)	2 μs or less
External Blanking	
Frequency Range	DC to 100 kHz
Voltage Level	Blanks at approximately +5 V to +20 V
Maximum Input Level	150 V (DC + peak AC)
Input Resistance	Approximately 100 kΩ

Characteristic	Performance Requirement
Power Supply	
Battery Pack	Six NiCd C Cells
Operating Time	3 to 7 hours, depending on display intensity, amplitude, and input signal frequency.
Charge Time (Full Charge)	Approximately 16 hours
External DC Supply	6 V to 16 V at 4.5 watts maximum
Line Voltage (to battery pack)	
Range	90 V to 136 V AC or 180 V to 272 V AC
Frequency	48 Hz to 400 Hz

POWER SOURCE REQUIREMENTS

The instrument requires an internal power pack, with NiCd batteries, or an external (+6 V to +16 V) DC source for power. A three position switch to the power pack selects either power source, and the battery charge rate when AC power is applied. The instrument will not operate from an AC power source if the battery is missing or defective.

Either 115 V or 230 V nominal AC line source can be used for AC powered operation. Connect the AC source to the battery pack with the power cord, then switch power source switch to AC/ BATT position. Refer to Figs. 1, 2, and 3 for power pack removal, fuse location and 115 V or 230 V AC hook-up instructions.

The battery can be charged with the power pack out of the instrument if desired. Extra power packs can, therefore, be charged to serve as spares. See Battery Care for instructions.

To operate the 323 from an external DC power source; set the power pack source switch to EXT DC position, connect a +6 to +16 volt DC source to the banana jacks above the line cord receptacle (observe polarity markings) and switch the front panel POWER switch to ON.

POWER PACK REPLACEMENT

WARNING

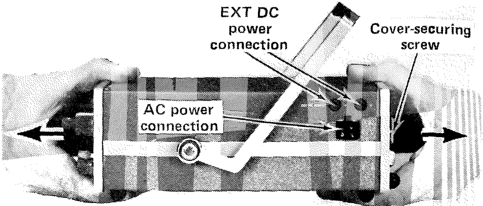
The power pack battery can deliver enough energy, if short circuited by such items as rings and watch bands, to produce severe burns. Switch the power selector switch to EXT DC position to reduce the number of points that have battery voltage or remove rings and other items before handling the power pack.

The 323 will not operate from the internal battery or an AC source if the selector switch is left in EXT DC position. The battery will, however, charge at full charge rate if AC Power is applied. Fig. 1 illustrates removal and replacement procedure.

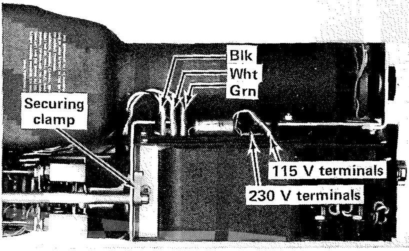
BATTERY CARE

The power pack uses six sealed NiCd cells connected in series for the battery. These cells require little maintenance, have high discharge rate, accept long term overcharging and operate over a relatively wide range of temperature. If properly cared for, you can expect about 500 to 600 charge/discharge cycles before their capacity drops to about 80% of specified value. Some of the more important battery characteristics and care are described below so maximum operating time between recharge cycles can be obtained.

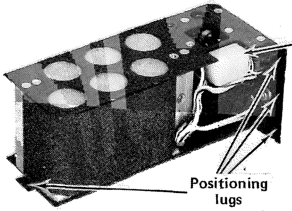
SELF DISCHARGE is a continuous process as long as the battery has any charge. The rate of self discharge depends on ambient temperature, state of charge, and impurities in the battery. Self-discharge at 45°C is approximately five times greater than it is at 20°C. A fully charged NiCd cell may lose 10% to 15% of full capacity during the first 24 hour period. This discharge rate decreases to about 0.68% per day or 10% to 15% per month after the initial discharge. To obtain the maximum



A. Loosen securing screw and pull dust cover off.

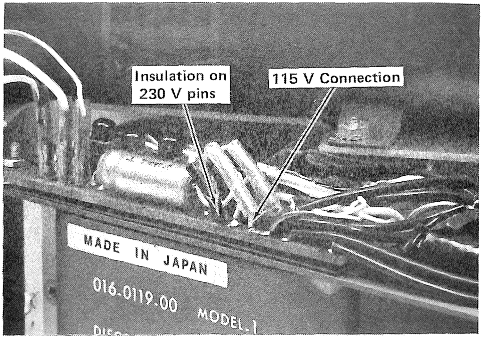


B. Disconnect interconnecting power leads. Release securing clamp.

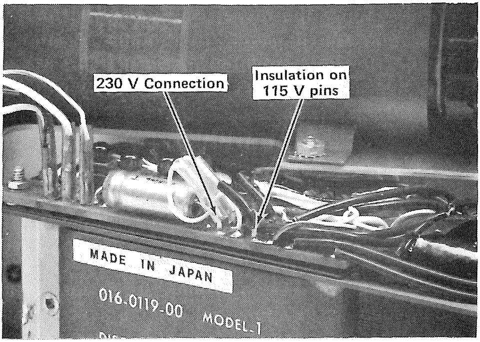


C. Power pack.

Fig. 1. Removing the battery power pack.



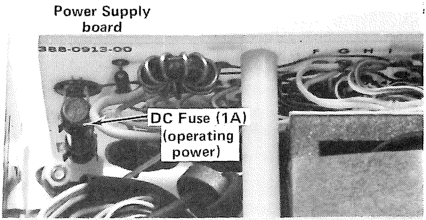
A. 115 V AC connection. Fuse size 0.25 A.



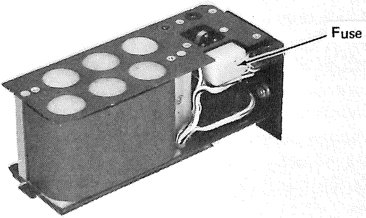
B. 230 V AC connection. Fuse size 0.125A.

Fig. 2. 115 V/230 V connections for Type 323.

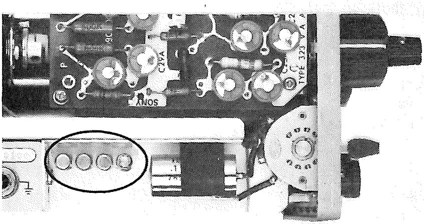
Remove cover



A. DC Fuse



B. AC Fuse



C. Spare fuses

Fig. 3. Fuse location.

operating time, the battery should be fully charged and maintained at this level by using the TRICKLE CHARGE feature to offset self-discharge until the pack is ready to use.

On FULL CHARGE, the power pack delivers a constant current that is approximately 1/10 the ampere hour rating of the cells in the battery. This charge rate allows the battery to be overcharged without cell damage. CHARGE TIME for the battery is about 14 to 16 hours at the FULL CHARGE rate.

OVERCHARGE is continued charging after the cells have reached full charge. Short periods of overcharging will cause no problems. During the overcharge period, the charge energy is dissipated as heat. If continued for an extended period (over 24 hours) it will dry the electrolyte.

TRICKLE CHARGE maintains the battery or cell at full charge. It will not recharge the cells, because most of the current is used to recover the self-discharge current. Use TRICKLE CHG to maintain the full charge state of the cells.

OPERATING TIME is a function of temperature and charge state. You can expect about 4 hours of operation under average conditions. The LOW BATT indicator, on the front panel, indicates by blinking when the battery charge level has decreased about 90%. The battery voltage starts to

decrease rapidly at this point; therefore, operation should be terminated within 10 to 15 minutes or as soon as possible after the indicator starts to blink. This reduces the possibility of the cells becoming reverse charged. Reverse charging occurs when some cells overcome the charge of the weaker cells.

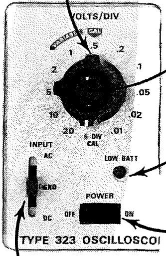
CHARGE BALANCING consists of charging the cells beyond the period required to bring them up to full charge. This balances the charge of the cells in the battery and reduces the possibility of any cells reverse charging. Once a month, or every 15 charge/discharge cycles, change the charge time to about 24 hours. After a cell has been replaced, the battery should be overcharged to balance the cells.

Avoid partial charges, if possible; however, if only a partial charge is practical, about 30 to 45 minutes of operation can be expected per 1 hour charge.

Additional data regarding maintenance and repair of the power pack and the NiCd cells is furnished in the standard manual.

FUNCTION OF CONTROLS AND CONNECTORS

Selects vertical deflection factor and a 5 div calibrator signal to calibrate X1 and X10 GAIN. Note effect on X10 VERT GAIN (front panel) switch on display.



Varies Volts/Div between calibrated steps. Range at least 2.5X.

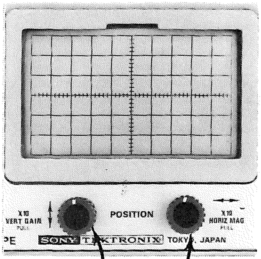
Flashes to indicate when battery charge state is close to discharge (refer to Battery Care).

Switches power to oscilloscope circuits, does not affect battery charging operation.

Selects input coupling from the VERT INPUT connector to oscilloscope vertical amplifiers.
AC—Low frequency cutoff is 2.0 Hz; 0.2 Hz with 10X probe.
GND—Oscilloscope amplifier input is grounded but not the signal conductor.
DC—DC signal component is applied to oscilloscope vertical amplifiers.

NOTE

Precharge feature allows rapid charge or discharge of input coupling capacitor. Useful for AC signals that ride on large DC voltage levels. Apply signal with selector at GND position, then switch to AC. Return to GND position before changing to a signal with a new or different DC level.



Positions the display vertically. Pulling the control out increases deflection factor X10. Bandwidth is reduced to 2.75 MHz with control out.

Positions display horizontally. Pulling the control out magnifies (10X) the center portion of the display, which effectively divides the indicated sweep rate (TIME/DIV) by 10. The portion of the display that is expanded is selected by the POSITION function of the control. An externally applied horizontal signal is amplified 10X when the control is pulled out.

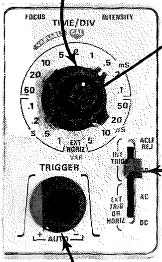
FOCUS and INTENSITY adjusted for sharp bright display. Brightness affects battery operating time.

Selects sweep (horizontal) rate. In EXT HORIZ position, horizontal deflection depends on signal applied to EXT HORIZ INPUT connector (side panel).

NOTE

For external horizontal sweep, the Trigger selector must be in the EXT TRIG OR HORIZ position.

Varies TIME/DIV between calibrated steps. Range at least 2.5X. When TIME/DIV selector is in EXT HORIZ mode, control attenuates horizontal signal from 1X to at least 10X.



INT TRIG triggers the display on the applied vertical signal.

ACLF REJ position; has low frequency cutoff at about 30 kHz.

AC positions; low frequency cutoff is about 30 Hz.

EXT TRIG triggers the display from signal applied to EXT INPUT connector (side panel).

AC position: low frequency cutoff is about 30 Hz.

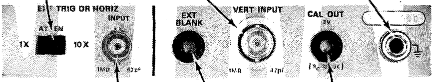
DC position: has no low frequency cutoff.

Selects trigger mode. In fully CCW or CW position, triggering is automatic on the + or — slope of the triggering signal. Between the two extreme positions, control selects triggering level on the + or — slope. Automatic triggering provides base line in the absence of triggering signal. Low frequency limit is approximately 30 Hz.

In 10X position the EXT TRIG OR HORIZ INPUT signal is attenuated by a factor of 10.

Connects to oscilloscope chassis. Provides a common ground return to signal source. Common ground must be provided to insure measurement reliability and to eliminate possibility of oscilloscope case rising to the signal source potential.

Vertical signal input



DC coupled input for blanking signal. Input level between +5 V and +20 V.

For external horizontal or triggering signal.

Source of 0.5 V calibrated square-wave.

Deflection sensitivity:

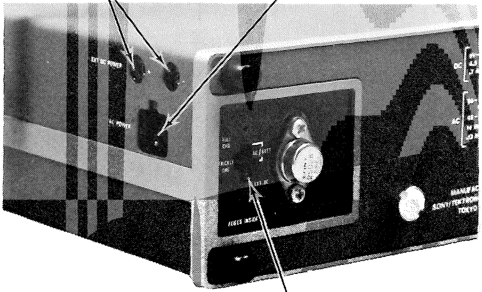
20 to 30 mV/div; ATTEN in 1X position and X10 HORIZ MAG pulled out.

200 to 300 mV/div; ATTEN 1X position and X10 HORIZ MAG pushed in, or ATTEN, 10X position, and X10 HORIZ MAG pulled out.

2 to 3 V/div; ATTEN, 10X position and X10 HORIZ MAG pushed in.

EXT DC POWER connectors (red +, and black −) for applying DC power source to the oscilloscope. Negative (−) connector is connected to oscilloscope case. DC voltage application does not charge the internal battery. Reversing the voltage polarity will blow the power pack fuse. Input voltage range is +6 V to +16 V. Surge current to 1 ampere.

Receptacle for applying AC power to charge the internal batteries and operate the oscilloscope. Line voltage range of 90 to 136 V or 180 to 272 V depends on the internal connection to the power transformer (see instructions for 115 V/230 V operation). Line frequency range 48 Hz to 440 Hz.



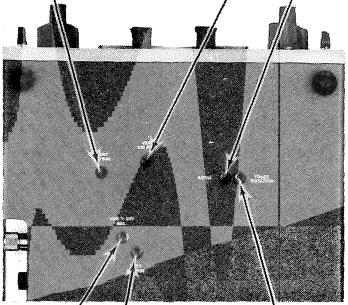
Selects battery charge rate or external DC power source.

With AC power applied, FULL CHG position will fully charge battery in 16 hours; TRICKLE CHG position will maintain but not increase charge level. In AC/BATT position, internal battery is power source for 323. In EXT DC position, battery is disconnected and an externally applied +6 V to +16 V DC source becomes the power source.

Astigmatism. Adjusts for optimum sharpness of vertical and horizontal lines at the same setting of the FOCUS control.

Adjusts (after VERT X1 GAIN has been adjusted) to provide calibrated gain factors with X10 VERT GAIN pulled out.

Adjusts for no trace shift accompanying switching between X1 and X10 positions of X10 VERT GAIN control, under no-signal conditions.



Adjusts the horizontal sweep path to parallel horizontal graticule lines.

Adjusts to provide calibrated gain factors with X10 VERT GAIN pushed in.

Adjusts for no trace shift during rotation of VARIABLE (VOLTS/DIV) knob, under no-signal conditions.

PERFORMANCE CHECK AND FAMILIARIZATION

This procedure provides a means of quickly checking operational performance of the 323. It will not check specified accuracies or completely check the instrument's performance; however, it should detect major inaccuracies or other malfunction. Refer to the Instruction Manual for complete information on a performance check or calibration. The Instruction Manual also includes troubleshooting procedure if this check indicates malfunctions within the 323.

CAUTION

1. Internal battery powered operation should be limited to 15 minutes or less after the LOW BATT indicator starts to flash. If the battery becomes sufficiently discharged, the indicator will stop flashing and the trace will disappear. Damage may occur if this happens; refer to the section on Battery Care. Replace the battery pack or connect it to the AC line source and recharge. Operation can continue during recharge if desired.

2. Refer to Specifications for voltage input levels and power source requirements.

Preliminary Procedure

Preset the front panel controls as illustrated in Fig. 4 and the Power Pack selector on the back panel to AC/BATT position.

1. Check Battery Charge Level

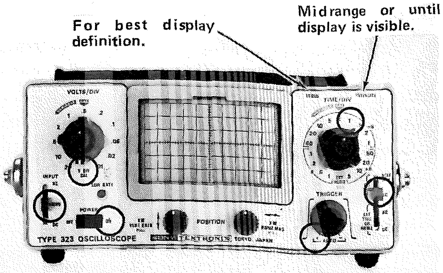
a. Switch POWER to ON position.

b. CHECK—Indicator should not flash. The lower portion of the calibrator signal should appear within the graticule area. Position the bottom and start of the display on the bottom graticule line and the 0 division (left) graticule line with the two POSITION controls. Re-adjust the FOCUS and INTENSITY controls for best focus and desired brightness.

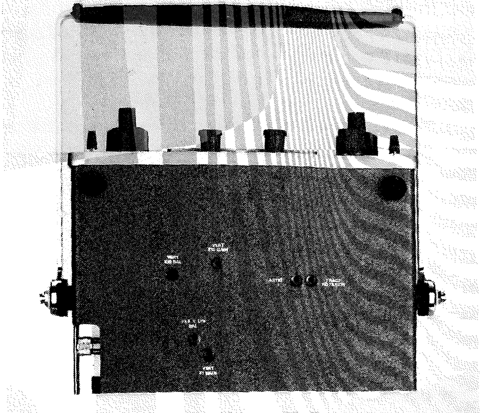
c. If LOW BATT indicator is flashing, batteries are discharged. Replace the battery pack (see Power Pack Replacement) or connect the power pack to an appropriate AC power source after checking to insure that the power pack is properly configured for your AC line voltage (see Fig. 2). Set the selector switch on the power pack to FULL CHG position. Proceed with the check after the battery has been charged or replaced.

NOTE

If desired, the 323 can be powered from an external DC source or from AC line source for the remaining checks. See Power Source Requirements.



A. Front panel.



B. Calibration adjustments on bottom panel.

Fig. 4. Front and bottom view of the controls and adjustments. Controls are set to provide a display.

2. Check/Adjust Astigmatism and Trace Rotation

a. With the INTENSITY adjusted for desired brightness, the calibrator display should be sharp and well focused.

b. Adjust—FOCUS control and Astigmatism (screwdriver adjustment, bottom of instrument, see Fig. 4) for optimum display sharpness.

c. Adjust—Trace Rotation to align the display with the graticule horizontal divisions.

3. Check/Adjust Vertical Deflection Factor

a. Position the bottom of the display at the bottom graticule line.

b. Check—The amplitude of the square wave display should equal 5 ±0.15 divisions.

c. Adjust—Vert X1 Gain (screwdriver adjustment, see Fig. 4) for a display amplitude of 5 divisions.

d. Pull out the X10 VERT GAIN control.

e. Check—The amplitude of the display should equal 5 ±0.15 divisions.

f. Adjust—Vert X10 Gain for display amplitude of 5 divisions.

g. Adjust—Vert X10 Bal for minimum display shift as the X10 VERT GAIN control is pulled out and pushed in. Push in the control to its X1 position.

h. Adjust—Var V/Div Bal for minimum baseline shift as the VARIABLE (VOLTS/DIV) control is rotated through its range.

i. Rotate VARIABLE (VOLTS/DIV) control fully CCW.

j. CHECK—Display amplitude should decrease to 2 divisions or less (2.5 X or more). Return the VARIABLE control to the CAL position.

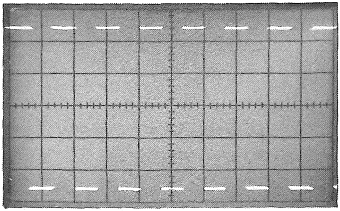
4. Check Volts/Div Calibration

a. Connect a P6049 probe to the VERT INPUT connector. Set the VOLTS/DIV selector to .01 and the TIME/DIV to 1 ms.

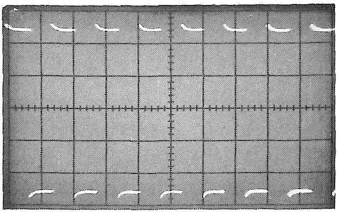
b. Touch the probe tip to the CAL OUT jack. Check the display for proper probe compensation and if necessary adjust the probe compensation for optimum front corner response to the square wave (see Fig. 5).

c. Check—Display amplitude should equal 5 divisions ±3%.

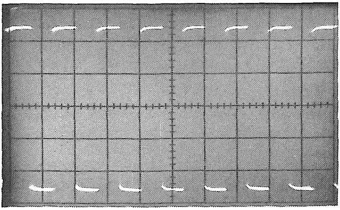
d. Switch the VOLTS/DIV selector to 0.2, then .05 positions.



(A) Correct



(B) Incorrect (overcompensated)



(C) Incorrect (undercompensated)

Fig. 5. Probe compensation.

e. Check—Display amplitude should decrease to 2.5, then 1.0 division.

f. Switch the VOLTS/DIV selector to .1 position and pull out the X10 VERT GAIN control.

g. Check—Accuracy of the .1, .2, and .5 selections of the VOLTS/DIV selector.

h. Switch the VOLTS/DIV selector to 1, and replace the P6049 probe with a banana jack to BNC jumper cable or 1X probe.

i. Check—The accuracy of the remaining VOLTS/DIV selector positions.

5. Check Trigger Sensitivity and Polarity

a. Switch the VOLTS/DIV selector to 1 ms, the Trigger selector to INT, AC position, pull out the X10 VERT GAIN control and apply the CAL signal to the VERT IN connector by means of the banana-plug-to-BNC jumper cable.

b. Adjust the VARIABLE VOLTS/DIV control for a display amplitude of 3 divisions.

c. Check—Trigger control operation on the +, then – slope of the input signal.

d. Push in the X10 VERT GAIN control (display amplitude should decrease to 0.3 division).

e. Check—Trigger sensitivity requirement by adjusting TRIGGER control for a triggered display.

6. Check EXT TRIGGER or HORIZ Operation

NOTE

In the EXT HORIZ mode, the internal sweep is disabled and the CRT is unblanked. Consequently, a brighter than normal stationary spot will appear on the face of the CRT unless an external sweep signal is applied. The INTENSITY setting should be changed to reduce the brightness level consistent with good viewing. Decreased intensity will also increase battery operating time.

a. Apply the CAL signal to the EXT TRIG OR HORIZ INPUT connector with the banana-plug-to-BNC jumper cable. Set the ATTEN switch to 1X position and the Trigger selector to EXT TRIG OR HORIZ position.

b. Check—External trigger operation by adjusting the TRIGGER level control through the + and − slope range for a triggered sweep.

c. Return the TRIGGER level control to AUTO position. Switch the TIME/DIV selector to EXT HORIZ position and decrease the INTENSITY setting to reduce the brightness of the two spots.

d. Check—Display span of the two spots should equal approximately 2 divisions ±20%.

e. Decrease the horizontal span of the two spots to 1 division with the VARIABLE (TIME/DIV) control.

f. Check—Horizontal magnifier operation by pulling out the X10 HORIZ MAG control. Note that the horizontal span increases to 10 divisions.

g. Switch the ATTEN selector (side panel) to the X10 position.

h. Check—Horizontal span of the two spots should decrease to 1 division.

i. Return the ATTEN switch to the X1 position and turn the VARIABLE (TIME/DIV) control fully CCW.

j. Check—Horizontal span of the two spots should decrease to 2 divisions or less (range of the control in EXT HORIZ mode is at least 10X).

k. Return the VARIABLE control to the CAL position.

MEASUREMENT TECHNIQUE

The following procedure describe a few operational techniques and measurements that can be used or made with the Type 323 oscilloscope.

Performance limitations on these techniques and measurements are described under Specifications for the instrument.

This instrument can also be used for many applications which are not described in this manual. Contact your local Tektronix Field Office or representative for assistance in making specific measurements. The following publications also describe oscilloscope measurement techniques which can be adapted for use with this instrument.

Tektronix FIP-7851, "A Primer of Waveforms and Their Oscilloscope Displays".

Harley Carter, "An Introduction to the Cathode Ray Oscilloscope", Phillips Technical Library, Cleaver-Hume Press Ltd., London, 1960.

J. Czech, "Oscilloscope Measuring Techniques", Phillips Technical Library, Springer-Verlag, New York, 1965.

Robert G. Middleton and L. Donald Payne, "Using the Oscilloscope in Industrial Electronics", Howard W. Sams & Co. Inc., The Bobbs-Merrill Company Inc., Indianapolis, 1961.

John F. Rider and Seymour D. Uslan, "Encyclopedia of Cathode-Ray Oscilloscopes and Their Uses", John F. Rider Publisher Inc., New York, 1959.

John F. Rider, "Obtaining and Interpreting Test Scope Traces", John F. Rider Publisher Inc., New York, 1959.

Rufus P. Turner, "Practical Oscilloscope Handbook", Volumes 1 and 2, John F. Rider Publisher Inc., New York, 1964.

Triggering The Display

The sweep for the Type 323 can be triggered from an internal or external source. Internal triggering is used for most applications on time, frequency, and amplitude measurements. It takes at least 0.3 division of signal level to trigger the sweep.

External triggering is used when comparing and/or time/phase measuring signals to a reference. Examples of this are; time sequence between signals in a pulse train, phase difference between input and output signals, time delay between signals at two or more points within a system, etc.

After selecting the triggering source, the method of coupling must be determined. Frequency limitations or ranges of the coupling positions are described under Function of the Controls. Use ACLF (AC low frequency reject) position to improve trigger stability when a trigger signal above 30 kHz contains low frequency components that interfere with the triggering. Use DC coupling for the external trigger, if a DC voltage is the triggering source.

Either manual or automatic triggering mode can be used with a choice of triggering on the (+) positive or (–) negative slope of the triggering signal. For most applications, automatic triggering is used because a sweep is generated when the trigger signal is absent. This allows the observer to see what is happening to the display or where the trace is located. In the AUTO mode, the trace locks to the trigger rate when trigger signal is present, and produces a stable display. It covers a wide amplitude range and permits rapid observation of many different signal levels and frequencies throughout a circuit.

Manual triggering is used for triggering signal frequencies below 30 Hz or when the exact triggering point is important. Triggering occurs on manual operation when the signal amplitude passes through the reference level and the + or – slope set by the TRIGGER control. Changing the trigger signal amplitude or TRIGGER level setting will affect the start of the sweep (see Fig. 6).

Manual triggering can also be used to trigger the display on single shot or erratic events.

To trigger internally on the input signal:

a. Set the Trigger selector to INT (AC) position, TRIGGER control to the + or – AUTO position.

b. Adjust VOLTS/DIV selector for a signal amplitude equal to or greater than 0.3 division. Triggering should automatically occur.

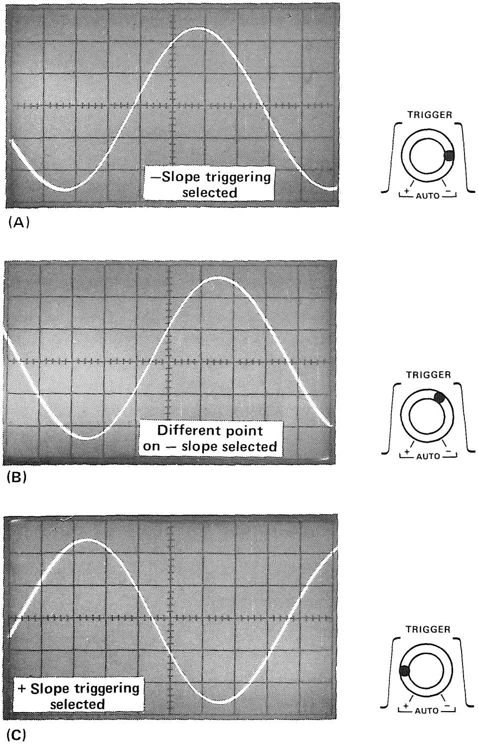


Fig. 6. Selecting trigger slope and amplitude.

c. If manual triggering is desired, adjust the TRIGGER control through the slope to the triggering level desired.

To trigger from an external trigger source:

a. Set the Trigger selector to EXT (AC) position, TRIGGER control to the + or – AUTO position.

b. Apply an external triggering signal, within 75 mV to 30 V (DC + peak AC) for the 1X position of the ATTEN selector, or 1 V to 300 V (DC + peak AC), for the 10X position of the ATTEN switch, to the EXT TRIG OR HORIZ INPUT connector.

c. If manual triggering is desired, adjust TRIGGER control through the slope to the trigger level desired.

Single Sweep Operation

For applications when the signal to be displayed is not repetitive, or varies in amplitude, shape, or time, it may be desired to use manual trigger operation so the sweep triggers only when there is a signal.

a. With the INPUT grounded or no signal present, turn the TRIGGER control to its most sensitive (lowest amplitude) setting where the trace no longer free runs.

b. Switch the INPUT selector to AC or DC position and apply the signal to the INPUT. An

external triggering signal that is sequential with the sporadic event may be applied to the EXT TRIG input, and extenral triggering used as described previously.

Internal and External Sweep Operation

Like triggering, most applications call for internal sweep operation. The internal sweep rate is controlled by the TIME/DIV selector which allows accurate time and frequency measurements when its VARIABLE control is in the CAL position.

External sweep or horizontal operation for the Type 323 can be used for X-Y displays and mating the oscilloscope to a swept frequency device such as a spectrum analyzer. The external horizontal sensitivity is 200 to 300 mV/division or 2 V to 3 V for a full screen (10 div) sweep. This sensitivity can be decreased by a factor of 10X with the ATTENuation switch or increased X10 by pulling out the X10 HORIZ MAG control. The VARIABLE (TIME/DIV) control provides an additional **10:1** range so an exact adjustment or calibration can be made of horizontal deflection factor for any combination of ATTEN and X10 HORIZ MAG settings. Maximum input voltage to the EXT connector is 300 V (DC + peak AC).

X-Y Displays: One signal is plotted with respect to another for lissajous patterns. These patterns provide exact phase and frequency relationship (see Type 323 Standard manual).

a. Set the TIME/DIV to EXT HORIZ position and the Trigger input selector to EXT TRIG OR HORIZ position (AC if the signal has a DC component, DC if the signal frequency is 30 Hz or less and within the input voltage limitation of the input).

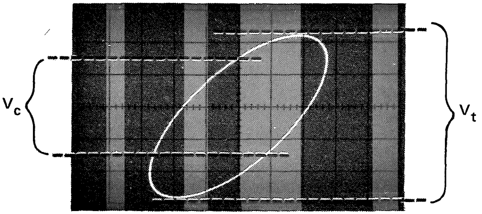
b. Switch the ATTEN and the X10 HORIZ MAG selectors to the appropriate position for the voltage level of the external horizontal signal.

c. Set the VOLTS/DIV and X10 VERT GAIN selectors to an appropriate position for the voltage level of the vertical signal.

d. Apply both X (horizontal) and Y (vertical) signals to their respective Input connectors and observe the display. (Fig. 7 illustrates one method of determining phase angle.)

NOTE

The vertical and horizontal amplifier characteristics must be considered in X-Y operation because of bandwidth and input impedance differences. The difference in phase shift between the two can be determined by applying the same signal to both inputs and calculating the phase difference as described in Fig. 7.



1. Center the display horizontally.
2. Measure total amplitude (V_t).
3. Measure center vertical line amplitude enclosed by ellipse (V_c).
4. Divide V_c by V_t to obtain sine of phase angle.
5. Determine phase angle from table of trigonometric values.
6. Angle is $> 270°$ and $< 090°$ if ellipse rises from left to right.
7. Angle is $> 090°$ and $< 270°$ if ellipse falls from left to right.

Fig. 7. Determining phase angle from X-Y display.

Sweeping the Display with External Sweep Voltage

a. Perform steps outlined for X-Y display.

b. Calibrate the horizontal scan for frequency/division by adjusting VARIABLE (VOLTS/DIV) control.

Selecting Sweep Rate and Use of the Magnifier

The sweep rate depends on the desired observation or measurement to be made. For frequency measurements, usually several cycles or events are displayed and the time between several cycles or events is measured (see Frequency Measurements). A portion of one cycle, or a full cycle, is usually displayed when measuring or observing small portions of a wavetrain, such as risetime, pulse duration, aberrations, etc. When parts of a waveform or wavetrain, that occur later than the sweep triggering are to be examined, the X10 HORIZ MAG can be used to expand the center portion of the display. The effective sweep rate, for the expanded portion, is decreased by a factor of 10; therefore, timing measurements must be divided by 10. Portions of the display you wish to expand should be centered with the POSITION control before pulling out the X10 HORIZ MAG control.

Signal Application to Vertical Input

For most applications the P6049 or similar probe should be used to interface between the oscilloscope vertical INPUT and the signal source. The probe increases the input resistance of the oscilloscope system to about 10 MΩ and decreases the capacitative loading to about 13.5 pF. The higher the impedance ratio between the input to the oscilloscope system and the signal source, the

less the circuit under test is loaded, and the more accurate the measurement. Because of circuit loading considerations, it is always best to select low impedance points in the circuit to make your measurements.

NOTE

To insure that measurements are accurate, always compensate the probe before using. Compensate the probe by touching the tip to the oscilloscope CAL OUT signal (on the side panel) and adjust the compensation adjustment for optimum front corner response to the 0.5 V square wave calibration signal (VOLTS/DIV setting .02, TIME/ DIV, 1 ms).

For applications where the source is a coaxial connector, such as the output of a signal generator, it is best to use a coaxial cable to interface between the oscilloscope and the signal source. In this application, loading is not a problem; however to preserve signal fidelity the cable impedance should equal the source impedance, and the cable should be terminated at the oscilloscope INPUT in its characteristic impedance.

It is always important to connect a common ground return between the signal source and the oscilloscope. When a probe is used, connect the

ground strap near the signal source to avoid long signal ground leads.

WARNING

If the Type 323 is battery powered and not connected to an AC power source, a ground return to earth potential should be provided. This return prevents the instrument case from rising to the signal source potential and becoming a possible safety hazard. It is best to connect a ground strap from the grounding connector on the side panel of the Type 323 to ground (earth) potential. This allows the probe tip to be moved to various test points without insuring that the probe shield is always connected to ground before or after the probe tip is connected to the signal source.

How to Measure Voltages

Properly compensate the probe before connecting it to the signal source. If a coaxial cable is used, terminate the cable at the oscilloscope INPUT in its characteristic impedance. Connect a common ground between the oscilloscope and the signal source.

1. AC Component Voltage

a. Set the INPUT selector to AC and the vertical deflection factor to an appropriate setting. (Verti-

cal deflection factor equals the product of the VOLTS/DIV setting and the probe or signal transporting lead attenuation factor.)

b. Select the desired TIME/DIV setting and adjust the TRIGGER control for a triggered display. Position the display within the graticule area for measurement.

c. Measure the peak to peak, or peak to trough, amplitude of the display or waveform, in graticule divisions (see Fig. 8).

d. Voltage (peak to peak) = Measured amplitude in divisions multiplied by the deflection factor (VOLTS/DIV X Probe attenuation factor).

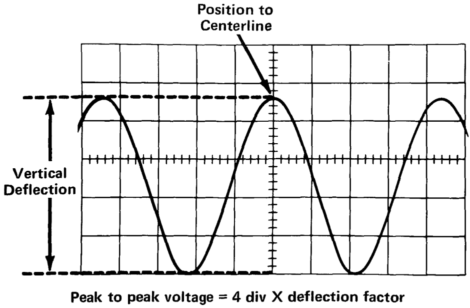


Fig. 8. Measuring peak-to-peak voltage.

NOTE

This technique may also be used to make measurements between two points on the waveform, rather than peak to peak.

2. Instantaneous Voltage Measurements

Instantaneous voltage is measured with respect to some reference potential (usually ground). This reference level is first established by positioning the trace along a graticule line with the reference potential applied to the input; then, the instantaneous voltage is applied and measured above or below the reference line or voltage (see Fig. 9). In

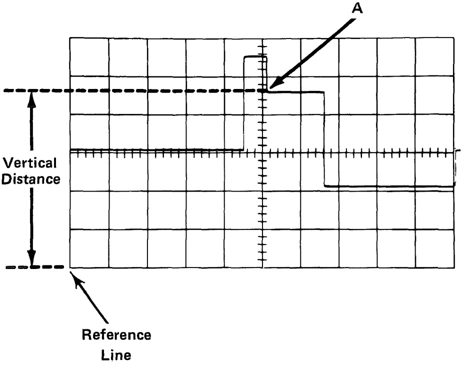


Fig. 9. Measuring instantaneous voltage with respect to a reference voltage. Voltage (point A) = Reference + (4.6 div. X vertical deflection factor).

this type of measurement, the INPUT selector switch must be in the DC position. This method can also be used to measure the DC component of a waveform, since the average or DC value can be measured as a voltage above the reference level.

a. Set the vertical deflection factor to an appropriate setting for the voltage to be measured, and set the TRIGGER control to AUTO.

b. Switch the INPUT selector to GND (if the reference is to be ground) or to DC (if the reference is a voltage level). Touch the probe tip to the voltage reference point, then vertically position the trace to a reference on a major line of the graticule. This reference position will depend on the polarity and amplitude of the input signal). Do not change the setting of the POSITION control after the reference has been set.

c. Remove the probe tip from the reference and connect it to the signal source. Adjust TIME/DIV selector for the desired display. (The probe ground should be near the signal source.)

d. Using the graticule, measure the vertical amplitude (in divisions) from the point to be measured to the reference line.

e. Voltage level equals measured amplitude (in divisions) multiplied by the deflection factor (see Fig. 9).

3. Voltage Comparison

For applications where the signal voltage is to be compared to some signal reference amplitude, it may be desirable to establish a different deflection factor than those available with the VOLTS/DIV selector. A conversion deflection factor constant, based on a specific reference amplitude, is established as follows:

a. Apply the reference signal of known amplitude to the INPUT.

b. Adjust the display amplitude to an exact number of graticule divisions using the VOLTS/DIV selector and its VARIABLE control. Do not change this setting after the reference has been established.

c. Deflection conversion factor constant equals:

$$\frac{\text{Reference signal voltage}}{\begin{pmatrix}\text{Volts/Div}\\ \text{setting}\end{pmatrix} \times \begin{pmatrix}\text{Display amplitude}\\ \text{in divisions}\end{pmatrix}}$$

d. Adjusted deflection factor for any setting of the VOLTS/DIV selection now equals, VOLTS/DIV setting multiplied by the conversion factor constant.

e. The peak to peak amplitude of any signal compared to this reference is measured as follows:

1) Set the VOLTS/DIV selector to a setting that will provide sufficient deflection to make a measurement. DO NOT MOVE THE VARIABLE CONTROL SETTING.

2) Signal amplitude =

Adjusted deflection factor	X	Signal deflection in divisions

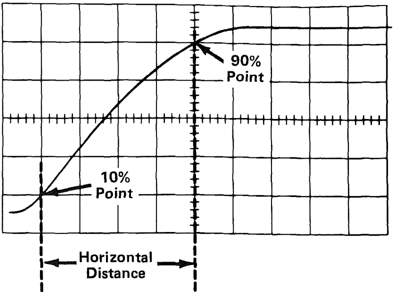
Time Measurements

The time base section is accurately calibrated; therefore, any horizontal distance represents real time. Time between two or more events can be measured directly on the graticule as follows:

a. Using the graticule, measure the horizontal distance between the two events.

b. Multiply the distance measured by the setting of the TIME/DIV control to obtain the apparent time interval. (The VARIABLE TIME/DIV control must be in the CAL position.)

c. Divide the apparent time interval by the MAGnifier setting to obtain the actual time interval (see Fig. 10).



$$\text{Time} = \frac{4 \text{ div X Time/Div setting}}{\text{MAGNIFIER setting}}$$

Fig. 10. Measuring time.

Frequency Measurements

By use of the methods described in the previous section, you can measure the period (time required for one cycle or time for a given number of cycles) of a recurrent waveform. The frequency of the waveform can then be easily calculated, since frequency is the reciprocal of the time period. For example, if the period of a recurrent waveform is accurately measured and found to be 20 microseconds, the frequency is 50 kHz. If the time for 10 cycles is 10 ms, the frequency is

$$\frac{1 \text{ X } 10}{10 \text{ ms}} \quad \text{or 1 kHz}$$

To calculate the period of a known frequency

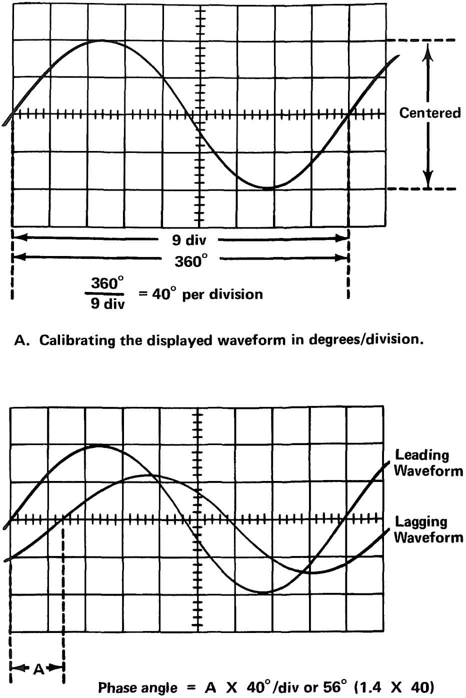
$$\text{Time} = \frac{1}{\text{Frequency}}$$

Phase Measurements

Since a complete cycle of a sinusodial waveform represents 360°, the oscilloscope graticule can be calibrated in degrees/division by using the TIME/DIV selector and its VARIABLE control. Adjust the span of a reference waveform so one cycle covers a given number of divisions. Fig. 11 illustrates how the graticule can be calibrated for 40°/Div. Phase angle of a signal from the reference now equals the displacement from the calibrated points on the graticule (see Fig. 11).

When making phase measurements, maintain a constant amplitude point on the input triggering signal so the two input signals are compared indirectly to this reference and directly to each other. The trigger signal must have sufficient amplitude to ensure stable triggering and frequency related to the waveforms on which phase measurements are to be made; however, the phase of the triggering signal is not critical. It is essential that after triggering conditions have been established, there is no change during any phase measurement.

The amplitude of the display should be large to improve accuracy. Accuracy of the measurements also depends on keeping the waveforms centered about the horizontal centerline of the graticule.



A. Calibrating the displayed waveform in degrees/division.

B. Phase angle between two waveforms. Note: the two displayed waveforms are not simultaneously on the screen.

Fig. 11. Phase angle calibration and measurement.

How to Use External Blanking (Z axis or intensity modulation)

Intensity modulation can supply additional information to a display without changing the X-Y information. Blanking is accomplished by applying a positive-going signal with an amplitude between +5 V and +20 V to the EXT BLANK connector. An example of this application is the use of an accurate frequency, applied to the Z axis, to serve as timing information on an uncalibrated horizontal sweep. However, the frequency must be time-related to the displayed waveform to produce a stable display.

COMMON OPERATIONAL ERRORS

If the instrument fails to function properly, it may be due to some operational oversight. The following checks will help assure that this is not the problem:

1. Check battery charge level.

2. Check position of the power pack selector switch (AC/BATT position unless an external DC power source is used).

3. Check control settings and cable connections against the initial setup instructions given for the Performance check at the front of this handbook.

4. Check fuses. See illustration for fuse location and size.